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# Lubrication

## A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

THE PACKARD ULTRAMATIC DRIVE

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**THE TEXAS COMPANY**

# LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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# THE PACKARD ULTRAMATIC DRIVE

THIS ISSUE will describe the Packard Ultramatic Drive which represents the first commercial application to an American passenger car of a combination torque converter-fluid coupling with a positive mechanical "high-gear" direct drive.

The Packard Ultramatic Drive was publicly announced April 28, 1949 as standard equipment on the Packard Custom Eight. As production capacity was increased it became optional equipment on the Super Eight and Deluxe Eight Series. At date of writing there are over 45,000 Packard Ultramatics in use, and over 90% of current Packard production is being Ultramatic equipped.

During preceding articles we have pointed out the following:

**PREVIOUS issues of this continuing series on American Automotive Hydraulic Transmissions have traced the development and commercial application of the fluid coupling[1], two different combinations of the fluid coupling with semi-automatic and automatic gear shifts[1]-[2], the multi-stage hydrokinetic torque converter[3], a combination torque converter-fluid coupling with automatic gear shift[4] and lastly a combination torque converter-fluid coupling with only an auxiliary transmission[5].**

## 1. Conventional Syncromesh Transmission

The conventional combination of a multi-step syncromesh transmission and friction clutch can provide any desired but permanently fixed torque-multiplication ratios with high transmission efficiency in each ratio, at comparatively low first cost. The principal disadvantage of the conventional transmission is that it is not automatically torque responsive, i.e. in addition to his many other duties the operator must be constantly alert to the torque demands of his vehicle and must estimate and physically shift into the particular gear which in his opinion will satisfactorily balance engine torque output against vehicle torque demand. If his estimate is poor, or if the vehicle torque demand has changed in the meantime because of the vagaries of traffic speed and terrain, then he must shift again and perhaps again. In short, the conventional transmission and clutch is best adapted to heavy vehicles operating on long non-stop hauls over relatively constant terrain; with such a transmission the efficiency of the equipment will be dependent upon such human qualities as experience, ability and judgment and may therefore decrease rapidly.

(1) Lubrication, November 1946, Automotive Hydraulic Transmissions.
(2) Lubrication, April 1947, The Hydra-Matic Transmission.
(3) Lubrication, November 1947, The Hydrokinetic Torque Converter.
(4) Lubrication, November 1948, The White Hydro Torque Drive.
(5) Lubrication, November 1949, The Buick Dynaflow Transmission.

## 2. Torque Converter

The hydrokinetic torque converter's principal advantage is that it is not only completely and automatically responsive to vehicle torque demands, but it is also able to instantly accurately, automatically, continuously and smoothly select and change to whatever torque multiplication ratio will satisfy both the engine's ability and the vehicle's requirements. Outside of its possible high initial cost, the principal disadvantage of the converter is its rapid loss of efficiency if the turbine-pump speed ratio is allowed to exceed approximately 0.8. To summarize, the torque converter in its simplest form is unequalled in its ability to replace and greatly surpass the lower gears of a transmission, but it is deficient in "high gear" operation unless (as is usually done) it is completely disconnected and superseded by an all-mechanical direct drive.

## 3. Fluid Coupling

Outside of its ability as a slipping clutch, the primary advantage of a fluid coupling is its ability to transmit torque at relatively high efficiency under "high gear" operation. Its principal disadvantage is its inability to multiply torque, consequently it must usually be used in conjunction with some other torque-multiplying device such as a mechanical gear box or a hydrokinetic torque converter.

## 4. Combination Converter Coupling

The prime advantage of the combination converter-coupling is that it combines the advantages of a hydrokinetic torque converter and fluid coupling. Such a combination is ample for normal driving in vehicles with high "engine torque to vehicle weight" ratios. Its principal disadvantage is that it is inclined to be somewhat hypersensitive to both driver and vehicle demands. For example, in the hands of an unsympathetic or ignorant driver it will give brilliant performance, but at the expense of reduced fuel economy. In other words the converter is eagerly ready and able to convert at a mere suggestion—often unconscious—from the driver.

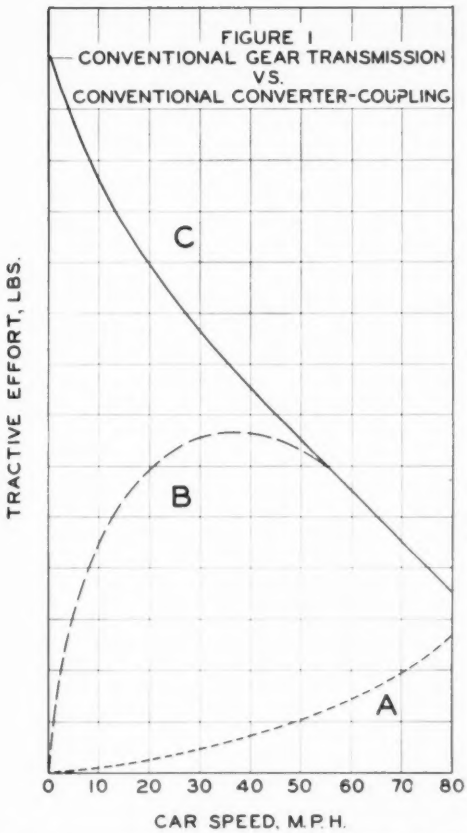
## Summary

Figure 1 will serve to summarize the problem and to suggest a solution. The figure presents three curves of actual test data plotted between car speed and tractive effort. Tractive effort is merely the force exerted by the car on the pavement while pushing itself along. Tractive effort could be measured by towing the vehicle steadily at the end of cable connected through a spring scale to a tow car, and the spring scale would directly measure the tractive effort of the towed vehicle. Obviously in normal operation under the same road conditions the car's engine with the assistance of the transmission and differential must generate an exactly equivalent force and apply it to the pavement at the point of contact with the tires.

Curve A shows the tractive effort required to move our test car along a level concrete road on a windless day at any chosen constant speed. This curve therefore represents the *minimum* tractive effort requirements for the car and additional tractive effort will be needed if we wish to accelerate the car to a higher speed, or if we should climb a hill, or drive against a head wind, or drive through sand, snow, or mud.

Curve B represents the maximum full throttle tractive effort of our test car equipped with a conventional synchromesh transmission in high gear. Since the curve starts at zero, we are forced to install a clutch which can be "slipped" to start the car moving while the engine is running at some higher speed further up the curve. (Even this subterfuge doesn't produce enough tractive effort at low speeds for hill climbing or reasonable acceleration hence the clutch must be supplemented with a geared transmission and a skillful driver to operate both.) The vertical distance between Curves A and B represents the "surplus" of tractive effort in our test car while in high gear and this surplus can be used for acceleration, and hill-climbing or for driving over poor roads or against head winds. Incidentally if the right hand or downward-curving portion of Curve B were extended so as to intersect Curve A, the point of intersection would mark the maximum top speed of our car on a level road and windless day. (Explanation: the tractive effort available equals the traffic effort required.)

Curve C presents the maximum performance characteristics of an efficient combination torque converter-fluid coupling when substituted for a conventional transmission in our test car. Notice how nicely it complements engine characteristics: at zero car speed when the engine with a conventional transmission would produce little or no tractive effort, the "stall" characteristic of the converter enables it to exert a tremendous tractive effort. As has been previously explained, with a torque converter engine speed is not mechanically "tied" to that of the car: on the contrary and with the car still motionless, the engine speed is allowed to rise immediately under full throttle to a speed that would correspond to about 35 miles per hour in high gear of a conventional transmission. As will be seen by reference again to Curve B, the resultant basic available tractive effort is close to the maximum of Curve B, and this basic tractive effort is then more than doubled by the converter. As car speed increases, engine speed also increases but at a lower rate: since the converter's multiplication ability is also decreasing, Curve C falls gradually and eventually joins and coincides with Curve B. (From these curves we could deduce that *under full throttle*, our con-




bination converter-coupling has completely changed to fluid coupling operation at a car speed of about 55 miles per hour.) Here then is a seemingly ideal automatic transmission that is able to automatically provide an infinite series of multiplication ratios between a powerful "low gear" and a straight through "high gear", and all without employing any gears, any shifts between gears, or any effort by the driver.

Before proceeding further let us emphasize that Curves "B" and "C" are full-throttle maximum performance curves which represent only full-throttle acceleration, and hill climbing. Curve A represents normal driving requirements. In a converter-equipped car we would therefore start the car at the uppermost tip of Curve C, and accelerate by continuing along it. Being sensible people however we would "slacken off" or "let up" our foot throttle as soon as the car's speed approached our desired steady driving speed. By slackening off the throttle we have reduced the engine's ability to generate tractive effort in an endeavor to approximate the tractive effort which the car requires for steady running at our chosen cruising speed. In other words and referring again to Figure 1, we have slid down some much steeper curve than C until we reached Curve A, and henceforth we try to keep on Curve A by minute adjustments of the foot throttle. If we open the throttle fully at any car speed we jump vertically from Curve A to C: unfortunately even a partial throttle opening has proportionally the same effect. Why do we say "unfortunately"?

We can never get something for nothing. "He who dances must pay the fiddler": he who dances on the foot throttle must pay the gasoline man and even the judge. For practical purposes tractive effort and gasoline consumption go hand in hand: if we demand high tractive effort, then we must expect to burn the additional gasoline which produces it. In a conventional transmission this lack of self-control may not be serious since the worst we can do is jump back and forth between Curves A and the relatively low Curve B. But consider what a price we could pay by putting a sensitive uninhibited driver behind an eager torque converter and surrounding the combination with red and green traffic lights, conniving cab drivers, and rearward horn blowers. In short, whether we wished to or not, we would have little choice but to oscillate all the way from Curves A and C and all points between at low average car speeds with consequent increased gasoline consumption.

After considering the foregoing logical series of developments, the reader-engineer will deduce that the next development in passenger-car automotive transmissions should start with the almost-perfect combination converter-coupling and would improve it by eliminating its hypersensitivity to driver and vehicle demand. This could be accomplished by devising a transmission of the converter-coupling type that during a normal start and acceleration would perform its functions as a converter and coupling, and then automatically eliminate itself by "locking up" into a highly-efficient all mechanical high gear. Furthermore and to eliminate over-eagerness or "hunting," our proposed transmission should *remain in high gear* until and unless it receives a definite intentional order from either the driver or the car that converter operation is again desired. Our proposed transmission is actually and already available in the Packard Ultramatic Drive.

## DESCRIPTION

### General

The Packard Ultramatic Drive is briefly (but not too clearly) described as a combination converter-coupling incorporating a hydraulically controlled and activated direct-drive clutch with an auxiliary compound planetary gear. The following paragraphs describe the principal component elements together with their associated control and operating devices in greater detail.

### Driver's Controls and Safety Provisions

Since the Ultramatic is a highly developed and

fully automatic mechanism, the driver needs only two devices to exercise his control over it: (1) the selector lever and (2) the conventional accelerator pedal or foot throttle. With the first the driver determines his desired *direction* (if any) of car movement; with the second, his desired *speed* of movement and its rapidity of attainment (acceleration). There is no clutch pedal, nor clutch nor gear shift of the conventional types since none are needed.

The selector lever is located on the right side of the steering column and is provided with a pointer and an illuminated quadrant to indicate the position as chosen by the driver. It is mechanically linked to the control valve of the Ultramatic Transmission. Reading from left to right on the quadrant the five possible selector lever positions are: "P" (Park, the selector itself being as far upwards as it will go), "N" (Neutral), "H" (High), "L" (Low), and "R" (Reverse, the selector lever being in its lowest position).

An electrical connection between the Ultramatic and the engine starter prevents the engine from being started unless the selector lever is in either the P (Park) or N (Neutral) position, an admirable safety feature.

The P (Park) position was expressly designed to supplement the hand brake when parking on a hill and is not recommended for normal level ground parking. In this position the propellor shaft and rear wheels are mechanically and rigidly locked stationary to the transmission case, hence a powerful bump from another car might cause breakage of the transmission case. Actual bump tests however have moved the car bodily with wheels locked and skidding without damage to the transmission. For the same reason it would be most inadvisable to shift into the "P" position while the car is still moving: to avoid this possibility together with similar but far less harmful accidental shift into "R" (Reverse), the selector lever mechanism is "gated" so as to require conscious effort by the driver in pulling and holding the lever towards him before moving it upward or downward into either the "P" or "R" positions. On the contrary the "N," "H" and "L" positions are all on the normal level of the gate which means that a simple one-finger vertical movement of the lever suffices to shift into any of them.

In the "N" (Neutral) position the engine is completely disconnected from the wheels and either or both can be turned independently of the other. Obviously this position is preferred for starting and idling the engine and the "N" (Neutral) position can be obtained or checked by touch only—by merely pushing the lever upwards as far as it will go.

The "H" (High) position provides the normal driving range which is so versatile in its abilities that it is used for at least 95% of all driving. As an example of its versatility in the "H" range the Ultramatic automatically provides the driving wheels with an infinite stepless series of driving torques ranging all the way from the equivalent of low gear in a conventional transmission to the equivalent of an overdrive. In high range the Ultramatic on the standard eight will start the car smoothly from a standing stop on the unbelievably steep grade of 25% (over 14 degrees), and the larger eights will negotiate 30% grades or more. Obviously, if low range is used, this hill climbing ability is almost doubled. Yet on level ground its overdrive characteristic amounts to almost 10% which is to say that its engine turns 10% less than a comparable car with a syncromesh transmission.

The "L" (Low) range is a super-powerful emergency low that is rarely needed but readily available for very heavy going in deep mud or steep mountain trails. The available wheel torque in this range is considerably greater than that of the lowest gear in a syncromesh gear box. For the ultimate in acceleration and a spectacular "jack rabbit" start, it is of course possible to start the car in the low range, and flip it into "H" range at any speed desired up to 40 mph.

The "R" (Reverse) range is obviously used for backing the car. As will be seen later the transmission construction is such as to permit the driver to "rock out" of a snow bank or mud hole by alternately flipping the selector lever from the adjacent "L" to "R" positions while keeping the throttle partly open.

While apparently of the conventional type, the foot accelerator or foot throttle is actually linked mechanically to both the carburetor and to the Ultramatic Transmission's throttle valve. As will be seen later, the throttle valve with several others permit the driver to choose within limits the car speed at which torque converter activity begins or ceases; in other words this valve simply and easily allows the driver to exercise control over the transmission. For example in normal part throttle driving the converter is automatically locked out at a car speed of 15 miles per hour but can be instantly returned to full duty at any speed up to 50 miles per hour by a full firm depression of the foot throttle.

## Combination Torque Converter — Fluid Coupling with Direct Drive Clutch

These two assemblies are so complementary in their functions, and are physically so close that they may well be discussed together. Furthermore they compose the real heart of the Ultramatic drive since they constitute a fairly complete automatic transmission within themselves and are wholly responsible for the Ultramatic's brilliant performance in the "H" range.

Figure 2 presents both a photographic cross section of the actual Ultramatic transmission and a highly schematic sketch of its principal mechanisms,

the corresponding parts in the two illustrations being connected by leader lines, part letters, and part names.

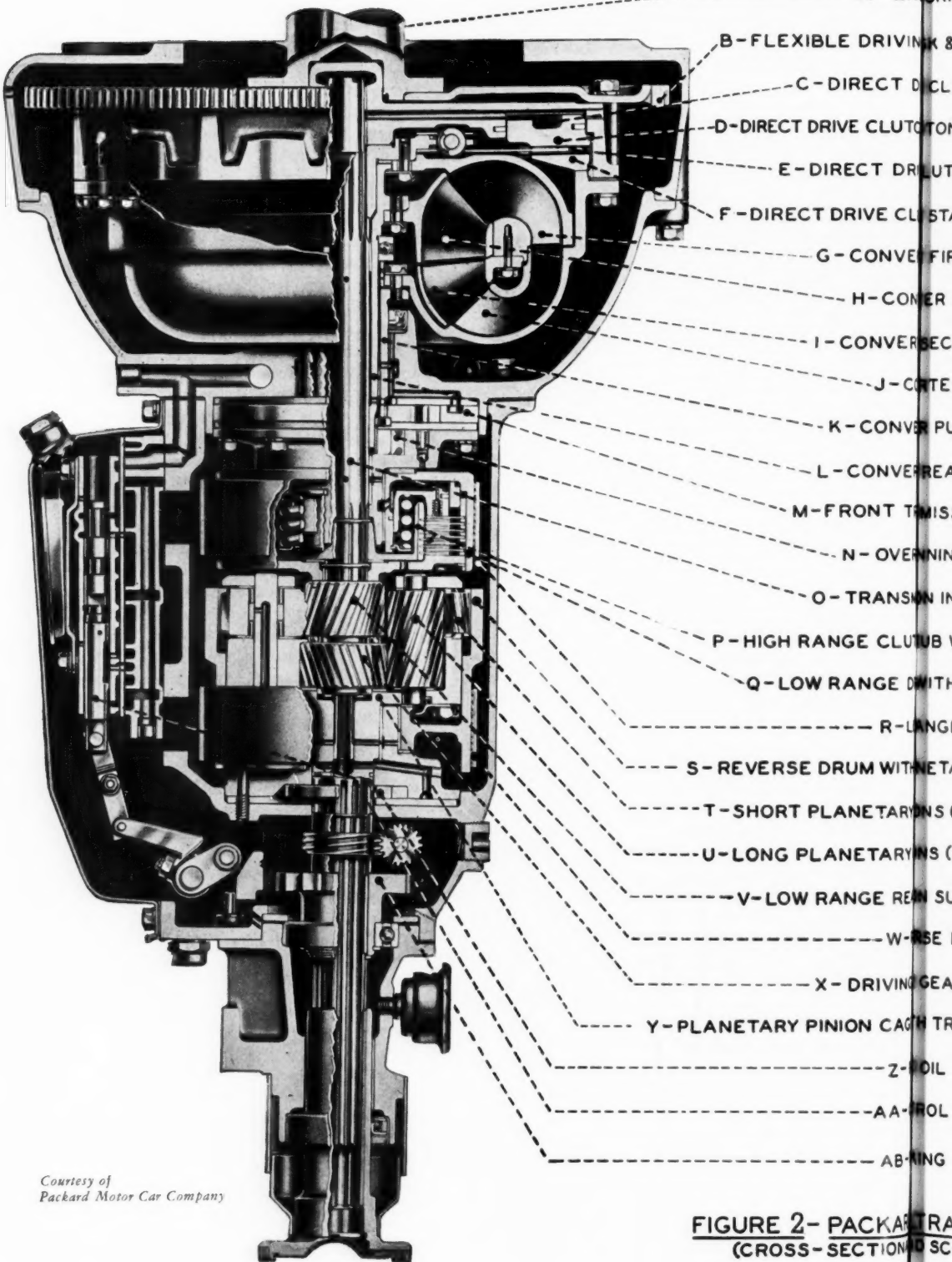
An examination of Figure 2 will show that the Converter-Coupling is composed of (1) the converter pump housing "J" with its internal pump blading, (2) the reactor "H" with its shaft "L" and over-running clutch "N", (3) the first turbine "G" splined to the transmission input shaft "O", and (4) the second turbine "I" which is ingeniously bolted to the first turbine. Precision aluminum castings are used in the pump, reactor and turbines. To clarify the illustration, considerable artistic liberty has been taken by schematically illustrating the reactor's overrunning clutch as a crude simple ratchet: actually of course it is a sprag-type clutch which automatically operates so smoothly and quietly that its action can not be detected. The reactor acts in the usual manner previously explained to change the converter into a fluid coupling: under part throttle road load conditions the fluid coupling becomes operative at a car speed of about 15 miles per hour. The use of *two* turbines and the ingenious assembly which interposes the reactor blading between these turbines are both unique: as a consequence this converter is not only able to multiply engine torque 2.4 times, but the coupling point and operating range of the converter is extended well up into normal driving speeds.

The Direct Drive Clutch is an hydraulically actuated wet single plate type having the following four important functions: (1) greatly improves transmission efficiency by isolating and deactivating the converter-coupling whenever its hydraulic torque multiplying and torque-transmitting are not required, thus preventing power losses caused by wasteful and profitless "windmilling" of converter blading; (2) provides a wholly-mechanical and highly efficient direct "high gear" drive which also removes the "rubber band" sensation usually associated with converter-couplings and frequently distasteful to certain drivers; (3) permits full utilization of engine compression as a brake when descending grades at speeds above 15 mph; (4) provides some unobtrusive restraint over the nervous throttle-juggling driver and considerably reduces the fuel consumption price that he would otherwise pay for his ineptness.

The direct drive clutch is contained within a malleable iron housing which is bolted around its periphery between the flexible driving disk ("B", Fig. 2) and the converter pump housing ("J", Fig. 2), the whole assembly therefore rotating at all times as one unit with the engine. The two ring-shaped clutch driving plates ("D" & "F", Fig. 2) are splined around their periphery to the inside of the clutch housing. The single cork-faced clutch driven plate ("E", Fig. 2) and the converter turbines ("G" & "I", Fig. 2) are both splined to the transmission input shaft ("O", Fig. 2). The left or moveable driving plate ("D", Fig. 2) is actually an annular piston with two piston rings, that moves axially within its cylinder ("C", Fig. 2) to lock the driven plate ("E", Fig. 2) between it and the stationary driving plate ("F", Fig. 2) whenever the transmission governor causes oil to be admitted into its cylinder ("C", Fig. 2). From further examination of Figure 2 it will be noted that when the direct drive clutch is engaged, the converter turbines are effectively locked to the converter pump and all elements of the converter-coupling and direct drive clutch then rotate as a single body, constituting in effect an oil-filled flywheel. Since the converter is completely filled with oil, and since there is no relative motion among the pump, turbine, and reactor blading, the oil is entirely quiescent and can neither contribute to nor adversely affect the efficient all-mechanical transmission of power between engine and rear wheels. When directed by the transmission control mechanism, the direct drive clutch is released by merely removing the activating oil pressure, and raising the converter pressure from 10psi (in direct drive) to 60 psi (in converter drive). Since these pressures are always exerted against the rear face of the direct drive clutch piston, the piston is immediately moved forward to completely disengage the direct drive clutch. This clever application of opposing oil pressures thus eliminates the multiple complex springs that are otherwise necessary to insure disengagement of such a clutch. A further interesting point of design is that the transmission governor is adjusted to engage the direct drive clutch shortly before the converter's clutch point: since the converter pump and turbine speeds are already approaching synchronism, very little synchronization is required of the direct drive clutch and it therefore engages so smoothly and quietly as to be undetectable to the average driver.

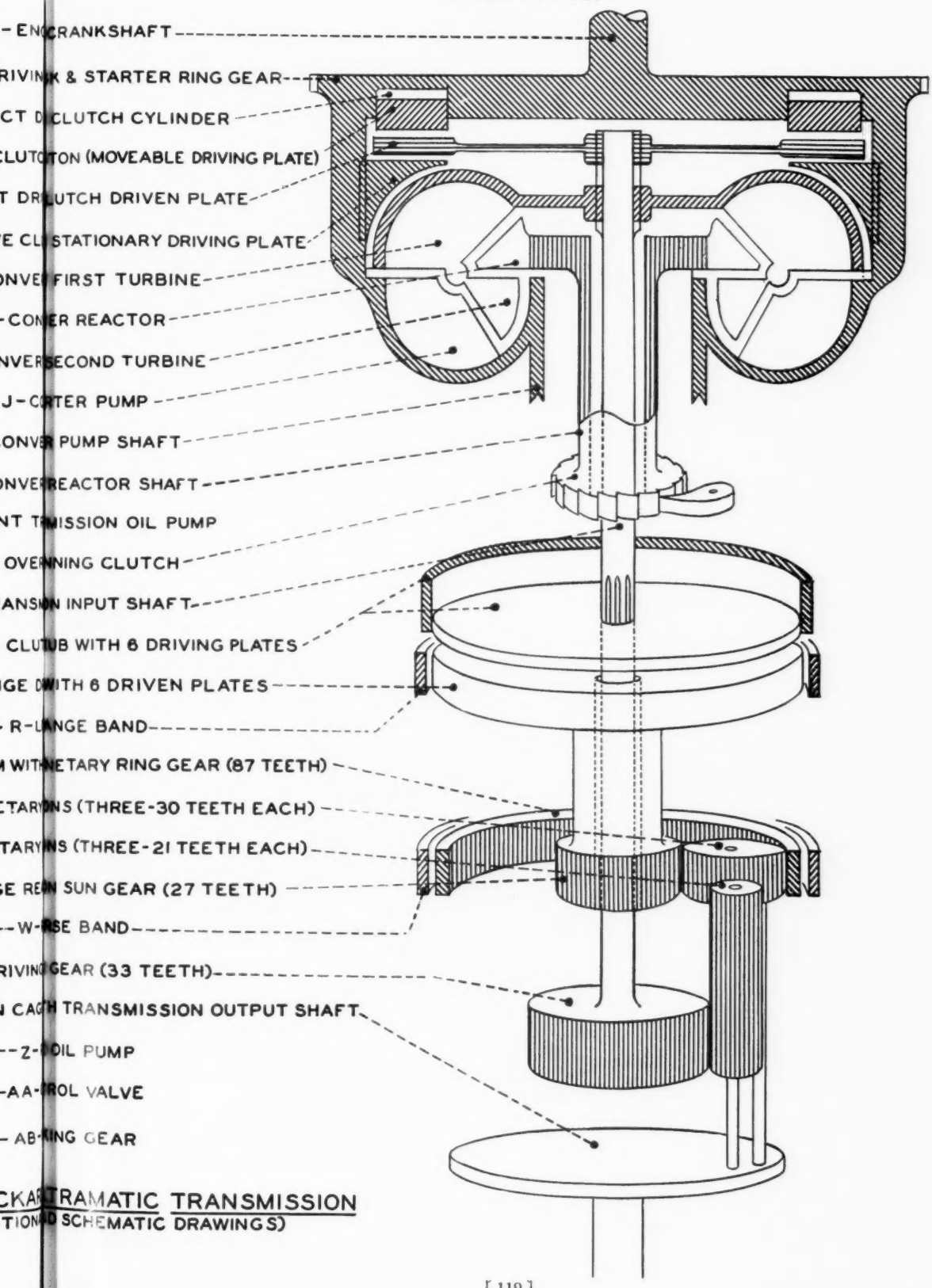
## Compound Planetary

Referring once more to Figure 2, the reader will notice that an auxiliary compound planetary gear controlled by two bands ("R", "W") and a multiple-disc wet clutch ("P", "Q") is used to provide a high or direct gear, a reverse gear, an emergency low range, a neutral and a parking position. (For purposes of simplicity the schematic drawing illustrates the multi-disc clutch as a simple single plate, and shows only one short and one long planetary pinion instead of the three each that are actually used.) The brake bands are of the single-wrap type which are postively applied and released through levers by double-acting "servo" hydraulic cylinders and pistons equipped with self-adjusting "take up" devices and located within the control valve body. The multiple disc clutch is applied by oil pressure exerted on its annual piston and disengaged by spring pressure. The following brief descriptions of


A - ENGRA
B - FLEXIBLE DRIVING K &
C - DIRECT DRIVE CL
D - DIRECT DRIVE CLUTCH TON
E - DIRECT DRIVE CLUT
F - DIRECT DRIVE CLUTCH STA
G - CONVERTER FIR
H - CONVERTER
I - CONVERTER SEC
J - CONVERTER
K - CONVERTER PU
L - CONVERTER REA
M - FRONT TRANSMIS
N - OVERRUNNIN
O - TRANSMISSION IN
P - HIGH RANGE CLUTCH
Q - LOW RANGE CLUTCH
R - RANGE
S - REVERSE DRUM WITH METAL
T - SHORT PLANETARY PINIONS
U - LONG PLANETARY PINIONS
V - LOW RANGE REAR SU
W - REAR
X - DRIVING GEAR
Y - PLANETARY PINION CAGE WITH TR
Z - OIL
AA - ROL
AB - RING

*Courtesy of*
*Packard Motor Car Company*

FIGURE 2 - PACKARD TRA
(CROSS-SECTIONAL SC




CKARTRAMATIC TRANSMISSION
TIONAD SCHEMATIC DRAWINGS)

the functions of the compound planetary are more easily understood by repeated reference to the schematic portion of Figure 2: the sub-paragraphs correspond to the positions of the steering column selector lever.

(1) "P" (Park). Mechanical linkage between the selector lever and transmission compresses a spring in the latter which forces a stationary pawl into the teeth of parking gear (AB) thus locking it and the rear wheels to the chassis. At the same time the direct drive clutch (C, D, E, F), high range clutch (P, Q), low range band (R) and reverse band (W) are all released, consequently the planetary is incapable of transmitting any torque, and in itself is in neutral position.

(2) "N" (Neutral). Both clutches and both bands are all released, consequently the gears in the planetary can merely idle aimlessly without transmitting any engine torque.

(3) "H" (High or normal driving). Within the planetary itself the high range clutch (P, Q) is engaged with both bands released, consequently the low range reaction sun gear (V) and driving sun gear (X) are both locked to the transmission input shaft (O), thereby locking the short and long planetary pinions (T, U) and the entire planetary revolves like a simple solid coupling merely transmitting engine or converter torque unchanged to the output shaft (Y). At car speeds below 15 mph and regardless of throttle position the direct drive clutch (C, D, E, F) is disengaged and the drive is through the converter-coupling: at higher speeds and part throttle, the direct drive clutch (C, D, E, F) engages, thereby isolating the converter-coupling, and engine torque is transmitted unchanged through the Ultramatic by direct wholly-mechanical drive. If the foot throttle is fully depressed at any car speed between 15 and 50 mph for purposes of acceleration or hill climbing the direct drive clutch (C, D, E, F) is disengaged, and the converter comes back into operation. The torque-multiplying ability of the Ultramatic in the "H" range therefore varies between 2.4 and 1 (direct drive) depending upon car speed, throttle position and road grade. By comparison the average low and intermediate gear ratios used in 1949 cars having ordinary synchromesh transmissions were 2.66 and 1.66 respectively which serves to illustrate how nicely the Ultramatic torque converter by itself has replaced two gears. This wide range of ability permits the use of a more direct rear axle ratio: in other words the Ultramatic in effect also has a built-in overdrive with consequent improved fuel economy and decreased engine noise during normal part-throttle driving.

(4) "L" (Low). Within the planetary the low range band (R) is applied, thus holding the low range reaction sun gear (V) stationary, while the high range clutch (P, Q) and reverse brake band (W) are both released. As a consequence the driving sun gear (X) drives the long planetary pinions (U) which drive the short planetary pinions (T). Since the low range reaction sun gear is stationary, the short pinions "precess" around it, carrying their planetary pinion cage (Y) in the same direction but at a lower speed than the driving sun gear with a resultant torque multiplication of 1.818. Obviously the reverse drum and planetary ring gear (S) also rotates idly in the same direction. The direct drive clutch (C, D, E, F) is disengaged and the converter comes into operation at car speeds below 15 mph or under full throttle up to 50 mph. The maximum full throttle torque multiplication ratio of the entire transmission (the product of the maximum converter and planetary ratios) is therefore $\frac{2.4}{1} \times \frac{1.818}{1}$ or $\frac{4.36}{1}$ which is considerably more powerful than either 2.66 or 1.66 which were the average ratios used in the low and intermediate gears respectively of 1949 cars equipped with the ordinary synchromesh manual type transmissions.

(5) "R" (Reverse). Within the planetary, the reverse brake band (W) is applied while the low range brake band (R) and high range clutch (P, Q) are released. The driving sun gear (X) therefore rotates the long planetary pinions (U) which in turn drive the short planetary pinions (T). Since the reverse drum and planetary ring gear (S) is held stationary the short pinions precess within it and rotate the planetary pinion cage (Y) in a direction opposite to that of the driving sun gear (X), thus providing both reversal of engine rotation and a torque multiplication of 1.637/1. Incidentally, the low range reaction sun gear (V) is not restrained and therefore able to rotate idly and rapidly in a reverse direction. With the converter in operation, the maximum torque-multiplication ratio of the entire transmission is therefore 2.4 x 1.637 or 3.93 which is considerably more powerful than 3.41, the average reverse ratio used during 1949 in the ordinary synchromesh manual-type transmissions.

## Hydraulic Control and Lubrication System

The function of the all-hydraulic control system is to apply or disengage under appropriate conditions the direct drive clutch and two bands and clutch which control the compound planetary. Since no gear shifts are necessary while the car is moving, the usually difficult and critical problems of synchronization and timing have been avoided thereby. The considerable development work on the system has therefore been largely devoted to obtaining the ultimate in smoothness and quietness of operation. The principal elements of the system are diagrammed in Figure 3 which also illustrates the

actual positions of the various elements when the transmission is operating in High Range and Converter, as when a full throttle acceleration is made during normal driving.

The hydraulic system comprises two oil pumps with a common intake screen, eleven valves, a governor, oil cooler and of course the requisite connecting oil passages. All but the two valves specifically excepted in the following descriptions are contained within the intricately-cored cast aluminum control valve body (which is partially sectioned in Figure 2), and the consequent total absence of extraneous tubing is impressive.

The Front Oil Pump (M, Figure 2) is of the rotary design and driven by the engine through an extension of the converter pump shaft (K, Figure 2), consequently it supplies oil to the transmission during idling and low car speeds.

The Rear Oil Pump (Z, Figure 2) is also of the rotary type but of about half the capacity of the front pump and driven by transmission output shaft (Y, Figure 2), consequently it discharges only when the car is moving forward and its capacity increases as car speed increases with the result that it is able to take over the transmissions requirements at speeds above 20 mph.

The Pump Check Valve is of the piston type placed in the discharge lines of both oil pumps and is free to move back and forth in conformance to the combined effects of the two pump discharge pressures. At car speeds below approximately 20 miles per hour, the valve occupies the position shown in Figure 3 when the front pump is delivering oil to the pump selector valve: at greater car speeds, when the rear pump has attained sufficient capacity, the check valve moves to the reader's left which cuts out the front pump and brings the rear pump into effective action as the new supplier to the transmission.

The Pump Selector Valve is of the piston type with two control springs: as indicated by its name its function is to *select* which of the two oil pumps will supply the transmission and to collaborate with the pump check valve and front pump relief valve in controlling the pumps. Figure 3 illustrates it in its normal low-car-speed position in which it has chosen the front (engine-driven) pump and is causing the pump relief valve to regulate its discharge pressure at about 85 psi. When the capacity of the rear (wheel-driven) pump has risen sufficiently the selector valve moves further to the reader's right where it (1) regulates the discharge pressure of the rear pump at approximately 93 psi and (2) causes the front pump discharge to bypass into its own inlet at about 15 psi, thus effectively reducing power absorption of the now-idle front pump.

When the selector lever (and control valve) are moved to the "R" (Reverse) position, oil at full pump pressure is applied to the right or spring side of the pump selector valve; this oil pressure added to the spring pressure doubles the oil pressure required from the front pump thus regulating its discharge pressure at 170 psi during reverse operation. This higher pressure is principally desired to insure against slippage of the reverse brake band, however it is incidentally applied elsewhere such as to the converter.

The Front Pump Relief Valve, located in the transmission bell housing close to the front pump is controlled both by a calibrated spring and by oil pressure from the pump selector valve. As previously noted it collaborates with the pump selector valve in controlling the front pump.

The combined function of the two pumps and the pump check, pump selector and front pump relief valves thus far described is to furnish oil at controlled relatively-constant pressure. The following valves and the remainder of the system either utilize this pressure unchanged or decrease it for specific purposes.

The Control Valve is of the piston type, linked mechanically to the steering column selector lever so that it merely transmits the driver's choice of *direction* of travel. Its 4 grooves, 5 lands and 6 notches conduct oil to the various operating devices required, and at the same time disconnects those that are not required.

The Throttle Valve (shown in its closed-throttle position) consists of an independent spring-loaded piston sleeve and a central balanced plunger, the latter mechanically linked to the foot throttle: the assemblies' function is to reduce constant pump pressure to a variable value which is proportional at all times to throttle opening, being lowest for closed throttle. As will be seen later this variable oil pressure (26 psi min. to 58 psi max.) is used in conjunction with the two following devices to determine at what car speed and throttle opening the direct drive clutch will engage or disengage.

The Governor is physically located at the right rear of the Ultramatic and is driven at a speed proportional to the car's by the transmission output shaft. It contains two spring-loaded valves which are also subjected to centrifugal forces and rear pump oil pressure, the whole assembly operating to produce a reduced oil pressure which varies proportionally to car speed (Representative values are 29 psi at 15 mph and 61 psi at 56 mph).

The Direct Drive Clutch Shift Valve assembly consists of the piston type shift valve itself and a separate shift valve piston located in the same bore. Governor oil pressure on the right end of the piston (Figure 3) is opposed by throttle valve oil pressure on the left: whenever the former exceeds the latter, the piston pushes the valve to the left thus admitting oil under pressure from the modulating valve to the direct drive clutch and engaging it.

At the same time the direct drive shift valve applies oil pressure to and closes the converter inlet valve (to be described later), which reduces oil pressure in the converter from 60 to 10 pounds during its idle condition. At speeds below 50 mph if the throttle is fully opened to obtain converter operation, the throttle valve allows full pump pressure to be applied to the left face of the shift valve: since at moderate speeds the pump pressure considerably exceeds governor pressure, the shift valve will immediately move to the right, disengaging the direct drive clutch and recharging the converter with full operating pressure. Above about 50 miles per hour the reverse condition prevails, and a downshift into converter is thus wisely prevented. And in reverse operation the absence of any pressure in the rear pump and governor prevents the shift valve from budging from its right hand position, hence the direct-drive clutch can not be engaged and all reverse operation is always in converter.

A Modulating Valve of the hollow piston type is inserted in the same bore with the direct drive shift valve for the purpose of reducing pump pressure to a variable lower pressure which is directly proportional to throttle opening. This modulated pressure varies between 40 psi at closed throttle to full pump pressure (85 psi) at full throttle. The modulating valve is controlled by and operates similarly to the throttle valve itself, however the pressure-throttle opening curve of the modulating valve is much steeper and higher final pressures are attained. The principal purpose of the modulating valve is to enhance smooth engagement of the multi-disk High Range Clutch whenever the steering column selector is moved from any other position into "H," however its modulated pressure is also used (1) to engage the low range brake band in "L" range, (2) to insure disengagement and hold out the low range brake band in all other selector positions (3) in response to the Direct Drive Clutch Shift Valve to operate the converter inlet valve.

The use of *throttle-modulated* oil pressure in the Ultramatic to operate the direct drive clutch, high range clutch, and low range band is worthy of special note as a further contribution to smoothness since the low oil pressure at part throttle (40 to 50 psi) insures a very gradual smooth band application, while at the same time the high oil pressure available at full throttle (80 to 90 psi) insures the necessary quick and firm application.

The Timing Valve is provided to insure smoothness and lurch free operation whenever the steering column selector lever is moved from H to L or vice versa: in other words it insures synchronization between the engagement and disengagement of the high range clutch and low range band and incidentally prevents any tendency for the engine to run away during a full-throttle shift from L to H. The timing valve actually accomplishes its mission by slightly delaying the application or release of the low range brake band: it does not directly affect the high range clutch. The valve itself is of a hollow spring-loaded piston with two bands which cover or uncover several ports. The right end of the valve is *always* subjected to modulated oil pressure but through a restricting orifice which slows down or "dash-pots" any sudden movement of the valve in either direction. If the selector lever is in the H position (during either converter or direct drive) the left side of the timing valve is also subjected to modulated oil pressure, consequently its spring forces it to remain in the right-hand position shown in Figure 3, where it vents the low range piston. If the selector lever is moved to any other position however, which requires the application or removal of the low range brake band, the balancing pressure on the left side is removed and the valve moves relatively slowly to its left-hand position, thus admitting modulated oil pressure to the bottom or top of the low range brake piston.

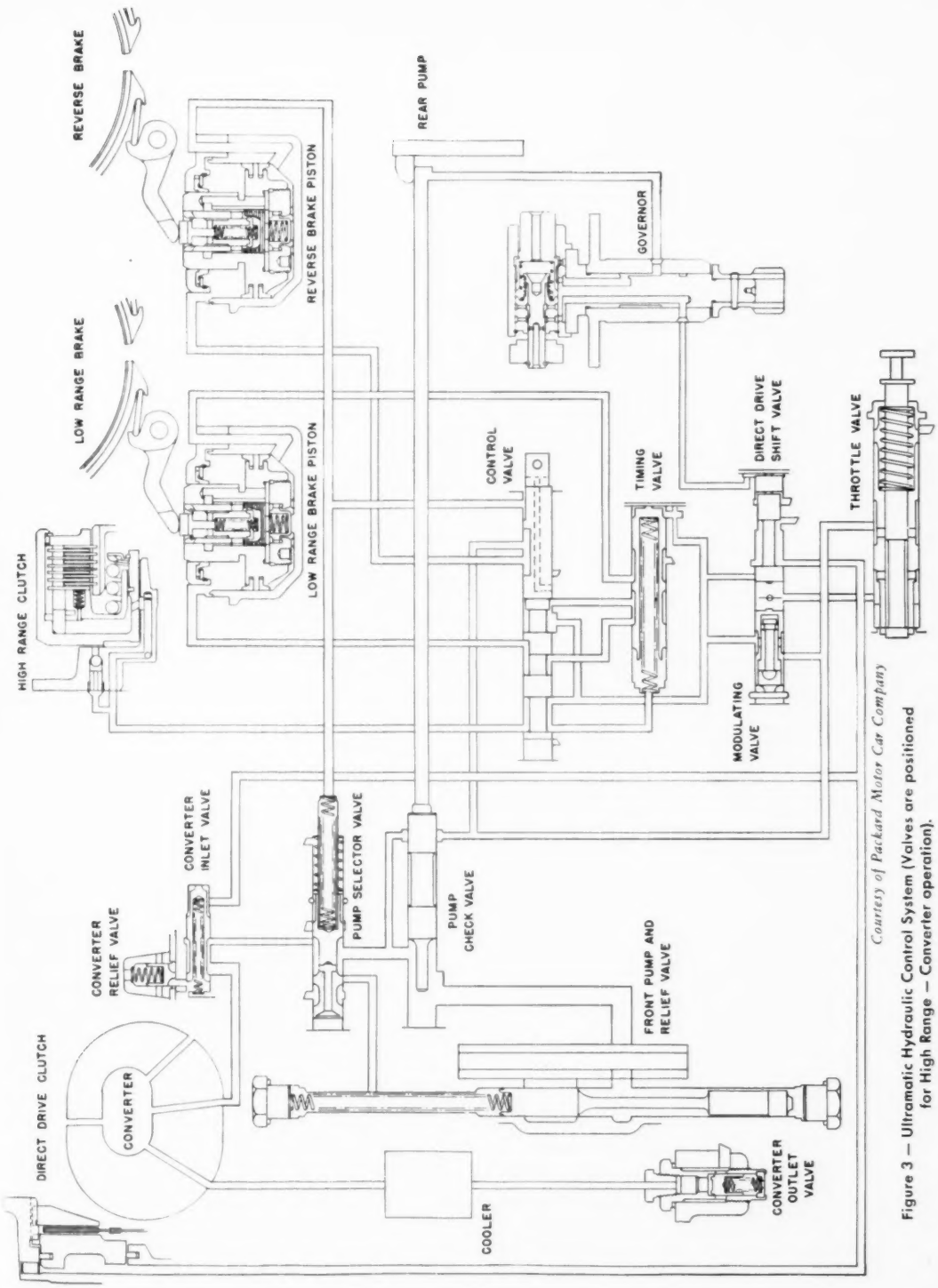
The remaining three valves in the hydraulic system all control the pressure and amount of oil circulation within the converter and are controlled in turn by the direct drive shift valve.

The Converter Inlet Valve is of the hollow piston type and is spring controlled to remain in its right-hand position as long as the direct drive shift valve is inoperative; in this position the valve admits oil at full pump pressure to the converter. Whenever the direct drive shift valve opens and applies modulated oil pressure to engage the direct drive clutch, the converter inlet valve is forced to the left thus reducing oil pressure in the converter from 60 psi to 10 psi which in turn decreases oil flow through the converter and increases transmission efficiency in direct drive.

The Converter Relief Valve, as its name implies, is a spring-loaded piston valve which when connected to the converter by the converter inlet valve, permits discharge of oil under direct clutch engagement when the oil is cold and delay would be experienced by discharging oil through the "official" cooler circuit.

The Converter Outlet Valve is also a spring-loaded piston located within a tubing fitting where the return line from the oil cooler enters the right side of the transmission case: its functions are to receive cool oil from the cooler, to discharge it into the sump, to prevent premature drainage out of the converter, and to slightly increase converter pressure.

The Oil Cooler or heat exchanger is of the multiple-tube oil-to-water type and is located in the bottom tank of the engine's radiator: it was provided only to control oil temperatures during the unusual condition of operating in converter for long periods of time, and is obviously unnecessary during normal driving.




*Courtesy of Packard Motor Car Company*

**Figure 3 — Ultramatic Hydraulic Control System (Valves are positioned for High Range — Converter operation).**

## Lubrication Requirements

From the foregoing description of the Ultramatic Drive it must be apparent that the twelve quarts of hydraulic fluid which it contains is a very important part of the transmission. The fluid not only has its own several fluid functions to perform but it must also assist and protect all of the associated mechanical parts. Since each separate function requires certain specific fluid properties, and since the same fluid is also widely used in other automatic transmissions which have somewhat different requirements, the task of successfully combining all of these necessary properties within a single fluid is so manifestly difficult that only a very few refiners have attempted its manufacture. Basically the fluid is a high quality mineral oil, but since no straight mineral oil is capable in itself of meeting all of the diverse requirements, the base oil must be reinforced with a considerable number of specialized chemicals, and the resulting blend is one of the most complex materials that is in general use. Keeping in mind that the primary requirement of the fluid is that it do its job in the transmission under a wide variety of operating conditions, the reader will realize that while the following properties are important and indicative of the general nature of the fluid, they are at best only superficial surface indications of the true quality beneath.

## Viscosity and Viscosity Index

The converter-coupling in itself would be satisfied with a very low viscosity; on the other hand the requirements of the associated pumps and valves, plain bearings and gears dictate a minimum viscosity of about 50 SU seconds at 210° F. Since the operating characteristics of any hydraulic system are modified by large variations in the viscosity of the operating fluid with changes in temperature, it is desirable that an all-season automatic transmission fluid have a high viscosity index.

## Pour Point

Unless its oil pumps are able to suck in and pump the vital fluid, the Ultramatic can not function. This is merely another way of saying that the fluid must have a pour point of at least Minus 35° F., the lowest winter temperature ordinarily encountered in this country.

## High Oxidation Resistance

At cruising speeds on level-roads the bulk fluid temperature in the Ultramatic will be but little higher than the radiator temperature: however under prolonged low speed hill climbing the fluid can develop a temperature of 300° F. Since the fluid is in constant circulation through the converter-coupling, transmission and cooler, it is continually exposed to and intimately mixed with atmospheric oxygen: this in combination with operating temperature is conducive to oxidation. However, the sludges or varnishes resulting from even a relatively small degree of oil oxidation would interfere with the proper operation of the hydraulic system and hence the transmission; therefore a high degree of oxidation resistance in the fluid, and its regular replacement every 10,000 miles are both paramount.

## Foam Resistance

As in most hydraulic systems, appreciable air-oil foam can not be tolerated in the Ultramatic since it interferes with the proper operation of the hydraulic control system, decreases the torque multiplication and transmission ability of the converter-coupling, promotes "spewing" or violent overflow and loss of fluid, depreciates or removes lubrication from bearings, and greatly increases intimate contact of the fluid with air thus promoting oxidation. As a consequence the fluid used in the Ultramatic has the highest resistance to foaming of any commonly used petroleum oil.

## Oiliness

The smooth (non-chattering) engagements of the direct drive clutch, high range clutch and low and reverse bands, are all accentuated by the presence of a fair degree of oiliness in the fluid. Furthermore the oiliness property is also of value during the initial operation of a new transmission, since it assists in "running in" the various parts.

## Chemical Activity

The fluid must not adversely affect any of the wide variety of metals, gasket materials, clutch facings or band liners used in the Ultramatic.

## Availability

The afore-described special fluid is not only used to test Packard Ultramatic Drives during production, but to make the initial fill of the completed units, and is Packard's sole recommendation for the subsequent regular service refill of the units in the field. Until recently and because of its complex nature and special properties, this fluid could be obtained only from Packard authorized service agencies under the name "Packard Ultramatic Drive Fluid" (Packard Part No. 410710, Group No. 3.507). Now however, Packard also recommends the equivalent "Automatic Transmission Fluid — Type A," which is widely available through petroleum company service stations.

Regardless of the petroleum refiners trade name, the words "Automatic Transmission Fluid — Type A" must always appear as part of the name, and the container must be stencilled or embossed with the letters AQ-ATF followed by a specification qualification number. The use of a product so marked should insure satisfactory and trouble-free transmission fluid performance, provided installation procedure and draining instructions are carefully adhered to.



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